भारतीय मानक
Indian Standard

IS 516 (Part 8/Sec 1) : 2020

दृढ़ीकृत कंक्रीट — परीक्षण पद्धतियाँ

भाग 8 लोचदार मापांक का निर्धारण

खण्ड 1 संपीड़न में अचल लोचदार मापांक और पॉयज़न अनुपात

(पहला पुनरीक्षण)

Hardened Concrete — Methods of Test

Part 8 Determination of Modulus of Elasticity

Section 1 Static Modulus of Elasticity and Poisson's Ratio in Compression

(First Revision)

ICS 91.100.30

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FOREWORD

This Indian Standard (Part 8/Section 1) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

Testing plays an important role in controlling the quality of cement concrete work. Systematic testing of the raw materials, the fresh concrete and the hardened concrete, is an inseparable part of any quality control programme for concrete. This helps achieve a higher efficiency of the materials used and greater assurance of the performance of concrete, in regard to workability, strength and durability. The test methods used should be simple, direct and convenient to apply. This standard was formulated with this objective in view.

This standard was first published in 1959. In this first revision, it was decided to review and update the various existing test methods of hardened concrete taking into consideration the latest international practices and developments in this field in the country, and also introduces certain new test methods wherever required. In the process, the various existing test methods covered in IS 516 : 1959 'Method of tests for strength of concrete' have been revised. The revision of this standard has been brought out taking into consideration primarily the corresponding ISO standards while also examining the other best practices world over and in the country. In addition, test methods for determination of additional properties have been included in areas such as permeability, initial surface absorption, corrosion of reinforcement, carbonation of concrete (field test), accelerated carbonation test, and, creep of concrete. Also, for better understanding and implementation, some of the other test methods for hardened concrete which were spread over in number of other Indian standards have been brought together under the fold of IS 516 as its various parts, such as the splitting tensile strength, ultrasonic pulse velocity test, rebound hammer test, bond in reinforced concrete, and determination of water soluble and acid soluble chlorides. This is with a view to making the standard complete in all respects, and rendering it a comprehensive source of provisions for testing of hardened concrete and reference in other Indian Standards.

In this revision, IS 516 is being split in to 12 parts. The other parts in this series are:

Part 1 Determination of strength of hardened concrete

Part 2 Determination of properties of hardened concrete other than strength

Part 3 Making, curing and determining compressive strength of accelerated cured concrete test specimens

Part 4 Sampling, preparing and testing of concrete cores

Part 5 Non-destructive testing of hardened concrete

Part 6 Determination of drying shrinkage and moisture movement of concrete samples

Part 7 Determination of creep of concrete cylinders in compression

Part 9 Determination of wear resistance

Part 10 Determination of bond in reinforced concrete

Part 11 Determination of Portland cement of hardened hydraulic cement concrete

Part 12 Determination of water soluble and acid soluble chlorides in hardened mortar and concrete

This standard (Part 8/Sec 1) covers the procedures for determination of static modulus of elasticity and Poisson's ratio for both cast as well as drilled/cut out specimens.

These test methods shall be applicable as and when published in place of the corresponding provisions given in IS 516 : 1959 and the same shall be superseded after the publication of all the parts of the standard.

This revision has been brought out to incorporate the modifications found necessary in the light of experience gained in its use and also to bring it in line with the latest development on the subject.

(*Continued to third cover*)

Indian Standard

HARDENED CONCRETE — METHODS OF TEST

PART 8 DETERMINATION OF MODULUS OF ELASTICITY

Section 1 Static Modulus of Elasticity and Poisson's Ratio in Compression

(First Revision)

1 SCOPE

This standard (Part 8/Sec 1) specifies a test method for the determination of the static modulus of elasticity and Poisson's ratio in compression of hardened concrete, on test specimens which are cast or taken from a structure.

2 REFERENCES

The standards listed below contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
516	Hardened concrete — Methods of test
(Part 1/Sec 1) : 2020	Testing of strength of hardened concrete Section 1 Compressive, flexural and split tensile strength of concrete (*first revision*)
(Part 4) : 2018	Sampling, preparing and testing of concrete cores (*first revision*)
1199	Fresh concrete — Methods of sampling, testing and analysis
(Part 5) : 2018	Making and curing of test specimens (*first revision*)
14858 : 2000	Requirements for compression testing machine used for testing of concrete and mortar

3 TERMINOLOGY

For the purposes of this document, the following terms and definitions apply.

3.1 Static Modulus of Elasticity in Compression of Hardened Concrete — Property of concrete, that corresponds to the tangent of the stress-strain curve.

NOTES

1 For design purposes the modulus of elasticity is considered equivalent to the chord modulus of deformation when the test specimen is loaded $F_c/9$ N/mm^2 and $F_c/3$ as described in this part of this standard. (F_c is the average cube compressive strength at 28 days age).

2 The modulus of elasticity can be considered as a modulus of deformation when the material is evaluated in the elastic range.

3.2 Poisson's Ratio in Compression — The ratio of transverse strain to longitudinal strain in a material subjected to loading.

3.3 Gauge Length — Each part of the test specimen, over which the strain or change in length is determined.

4 APPARATUS

4.1 Testing Machine

The test shall be carried out using a compression testing machine conforming to IS 14858. The test machine shall be in calibration at the time of test. The calibration shall be carried out at least once a year. The compression testing machine shall be capable of applying the specified rate 14 MPa/min and of maintaining it at the required level.

4.2 Strain Measuring Apparatus

Instruments for measuring the changes in length (B) (for example mirror or dial gauge extensometers, resistance strain gauges, inductance gauges, vibrating wire-strain gauges) shall have a gauge length of not less than two-thirds of the diameter of the test specimen (2/3 d) and shall not exceed its diameter (d). It shall be attached in such a way that the gauge points are equidistant from the two ends of the specimen and at a distance not less than one-quarter of the length of the test specimen (B/4) from its ends.

Measurements shall normally be taken on not less than two opposite sides of the specimen. With specimens cast in horizontal position, the gauge lengths shall be arranged on the vertical sides as cast.

The measuring apparatus shall have an accuracy of 5×10^{-6}.

Measuring gauge having a length of not less than 100 mm may have an accuracy of 10×10^{-6}.

4.3 Arrangement for Poisson's Ratio Determination

See **6.2**.

5 TEST SPECIMENS

5.1 General

a) *Cast specimens* — Two cylindrical specimens may be cast for modulus of elasticity determination and Poisson's ratio determination and three cube samples (150 mm side) of the same mix and batch may be cast for compressive strength determination as per IS 516 (Part 1/Sec 1).

b) *Specimens taken from a structure* — Three specimens shall be used to determine the modulus of elasticity, the Poisson's ratio and compressive strength. If taking specimens could pose a risk of damaging the structure, the number of specimens may be reduced to two. In this case, the compressive strength may be estimated from other information also.

5.2 Shape and Dimensions of Test Specimens

5.2.1 *For Compressive Strength*

The compressive strength cast specimen shall be cubes of side 150 mm. For drilled or cut out specimens from structures, the compressive strength specimens shall be cylinders with length to diameter ratio L/d preferably 2. In case, cylindrical specimens are used for strength determination, the equivalent cube compressive strength shall be determined as per **8** of IS 516 (Part 4) after applying necessary corrections for diameter, L/d ratio and for shape factor (cylindrical to cubical strength). In case of drilled out or cut specimens, if the number of specimens are not adequate for determining the compressive strength, then the compressive strength may be obtained from other information or records.

5.2.2 The specimens to be used for measuring the modulus of elasticity and Poisson's ratio shall comply with the following requirements:

a) The minimum dimension of moulded specimens shall be 100 mm and at least four times the nominal maximum size of the aggregate in the concrete, whichever is the larger value. Moulded test specimens shall preferably be cylinders 150 mm in diameter and 300 mm in height. Other specimens, may also be used, such as, prismatic specimens with a square cross section where L/w ranges from 2 to 4, where L is the length and w is the side of the specimen.

b) The minimum dimension of drilled or cut-outs of structure specimens shall be 100 mm and at least three times the nominal maximum size of the aggregate in the concrete, whichever is the larger value.

c) The length to diameter ratio of the test specimens shall preferably be 2 and may also vary between $L/d = 2$ to 4.

5.3 Preparation and Curing of Test Specimens

The making and curing of compression test specimens of concrete shall be as per IS 1199 (Part 5) and the testing shall be as per (IS 516 Part 1/Sec 1). The test specimen taken from a structure shall be prepared in accordance with IS 516 (Part 4).

5.4 Age of Test

Normally test shall be made when the specimens reach the age of 28 days. Wherever required, the testing may be done at other ages and age of testing shall be reported.

6 PROCEDURE

6.1 Modulus of Elasticity

Immediately on removing the cylinder or prism from the water and while it is still in a wet condition, the extensometers shall be attached in the longitudinal direction at the ends, or on opposite sides of the specimen and parallel to its axis, in such a way that the gauge points are symmetrical about the centre of the specimen and in no case are nearer to either end of the specimen than a distance equal to half the diameter or half the width of the specimen. The extensometers shall be fixed with the recording points at the same end. The specimen shall be immediately placed in the testing machine and accurately centred. The load shall be applied continuously and without shock at a rate of 14 N/mm^2/ min. Apply the basic stress of $F_c/9$ N/mm^2 (σ_b), maintain for 60 s, then measure and record the strain gauge readings taken at each measurement line.

Steadily increase the stress at a constant rate within the range 0.20 N/mm^2/s to 0.30 N/mm^2/s until the stress equals one-third of the 2:1 cylinder strength of the concrete ($\sigma_a = F_c/3$).

Maintain the stress for 60 s, then measure and record the strain readings taken during the succeeding 30 s at each measurement line. If the individual strains are not within a range of ± 20 percent of their mean value at σ_a, re-centre the test specimen and repeat the test. If it is not possible to reduce the differences to within this range do not proceed with test. When the centering is sufficiently accurate, reduce the load, at the same rate as during loading, to the level of the basic stress. Carry out at least two additional preloading cycles, using the same loading and unloading rate, and maintaining the stress (σ_a and σ_b) constant for a period of 60 s. After completion of the last preloading cycle and a waiting period of 60 s under the stress $\sigma_b = F_c/9$ N/mm^2 at the various measurement lines record the strain reading, ε_b, taken during the succeeding 30 s.

Reload the specimen to stress σ_a, maintain it for 60 s, at the specified rate, and at the various measurement lines measure and record the strain reading ε_a, taken within 30 s. When all elasticity measurements have been completed, increase the load on the test specimen, at the specified rate, until failure of the specimen occurs. If the compressive strength of the specimen differs from F_c by more than 20 percent, this shall be noted in the test report and it shall be reported that the result may not be reliable.

NOTE — The compressive strength may be determined after determining both the modulus of elasticity and the Poisson's ratio on the same sample, if both tests are to be carried out.

6.2 Poisson's Ratio

Immediately on removing the cylinder or prism from the water and while it is still in a wet condition, the extensometers shall be attached in the transverse direction on opposite sides of the specimen and parallel to its axis, in such a way that the gauge points are symmetrical about the centre of the specimen and in no case are nearer to either end of the specimen than a distance equal to half the diameter or half the width of the specimen. A combined system of extensometers in longitudinal and transverse direction (*see* Fig. 1) can also be used, this apparatus shall contain a third yoke (consisting of two equal segments) located halfway between the two extensometers yokes and attached to the specimen at two diametrically opposite points. Midway between these points use a short pivot rod, adjacent to the long pivot rod, to maintain a constant distance between the bottom and middle yokes. Hinge the middle yoke at the pivot point to permit rotation of two segments of the yoke in the horizontal plane. If the distances of the hinge and the gauge from the vertical plane passing through the support points of the middle yoke are equal, the transverse deformation of the specimen diameter is equal to the one half of gauge reading. The specimen shall be immediately placed in the testing machine and accurately centered. The load shall be applied continuously and without shock at a rate of 14 N/mm^2/min. Apply the basic stress of F_c/9 N/mm^2 (σ_b), maintain for 60 s, then measure and record the strain gauge readings taken at each measurement line.

Steadily increase the stress at a constant rate within the range 0.20 N/mm^2/s to 0.30 N/mm^2/s until the stress equals one-third of the 2:1 cylinder strength of the concrete ($\sigma_a = F_c/3$).

Maintains the stress for 60 s, then measure and record the strain readings taken during the succeeding 30 s at each measurement line. If the individual strains are not within a range of ± 20 percent of their mean value at σ_a, recentre the test specimen and repeat the test. If it is not possible to reduce the differences to within this range, do not proceed with test. When the centering is sufficiently accurate, reduce the load at the same rate as during loading, to the level of the basic stress. Carry out at least two additional preloading cycles, using the same loading and unloading rate, and maintaining the stress (σ_a and σ_b) constant for a period of 60 s. After completion of the last preloading cycle and a waiting period of 60 s under the stress $\sigma_b = F_c/9$ N/mm^2 at the various measurement lines, record the strain reading, ε_b, taken during the succeeding 30 s.

Reload the specimen to stress σ_a, maintain it for 60 s, at the specified rate, and at the various measurement lines measure and record the strain reading ε_a, taken within 30 s. When all elasticity measurements have been completed, increase the load on the test specimen, at the specified rate, until failure of the specimen occurs. If the compressive strength of the specimen differs from F_c by more than 20 percent, this shall be noted in the test report and it shall be reported that the result may not be reliable.

FIG. 1 ARRANGEMENT FOR DETERMINATION OF POISSON'S RATIO

7 CALCULATION

Calculate the mean strain ε_a and ε_b respectively. When the strain and stress are continuously measured, ε_a shall be determined by interpolation. The modulus of elasticity in compression shall be calculated as follows:

$$E_c = \frac{\sigma_a - \sigma_b}{\varepsilon_a - \varepsilon_b}$$

where, σ_a is the upper loading stress, in N/mm^2 (MPa).

$\sigma_a = F_c/3$

σ_b is the basic stress = $F_c/9$ N/mm^2

The Poisson's ratio in compression shall be calculated as follows:

$$P_r = \frac{\Delta \text{ transverse strain}}{\Delta \text{ longitudinal stain}}$$

$$= \frac{\text{Transverse strain at } \sigma_a - \text{Transverse strain at } \sigma_b}{\text{Longitudinal strain at } \sigma_a - \text{Longitudinal strain at } \sigma_b}$$

Express the result, to the nearest three significant digit. Report both the individual determinations of the modulus of elasticity and Poisson's ratio for each specimen and the average value.

8 REPORT

The following information shall be included in the report:

a) Details of the concrete specimen, such as grade, cast or drilled/cut specimen,
b) Identification mark,
c) Date of test,
d) Age of specimen,
e) Shape and nominal dimension of specimen,
f) Modulus of elasticity,
g) Poisson's ratio, and
h) Remarks, such as number of loading cycles.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

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(*Continued from second cover*)

Significant modifications in this revision include,

a) introduction of procedure for determining Poisson's ratio.

b) simplification of method of calculation for modulus of elasticity by eliminating the graphical calculation and introducing formulae for the same.

c) elaboration of determination of compressive strength.

In the formulation of this standard, assistance has been derived from ISO 1920-10 : 2010 'Testing of concrete — Part 10: Determination of static modulus of elasticity in compression' and from ASTM C 469/C 469-14 "Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression".

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

In reporting the result of a test or analysis made in accordance with this standard, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical-values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that specified value in this standard.

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